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THE INFLUENCE OF LOW MOISTURE ON PLANT PARASITIC NEMATODES

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Nematodes are dependent on water for most activities. Free water that is in contact with nematodes is readily distributed in a film over their bodies, because they possess a hydrophyllic cuticle. Since most plant parasitic nematodes spend some phase of their life cycle in water films that surround soil particles, it is not surprising that fluctuations in nematode populations can be correlated with fluctuations of soil moisture. However, there are many factors that interact with soil moisture and alter the response of nematodes. Some species of nematodes have developed mechanisms to survive very dry conditions for extended periods of time. Therefore, an understanding of the sensitivity of each plant parasitic nematode to low soil moisture is fundamental for developing adequate sanitation practices and other control procedures.

Evidence That Low Moisture Reduces Nematode Populations

Optimum moisture levels for nematode movement in the soil and penetration of host roots varies with each species, but generally optimum moisture levels occur near field capacity. At lower moisture levels these activities are greatly reduced. It has been shown that movement and the invasion of host roots by *Pratylenchus penetrans* (lesion), *Meloidogyne hapla* (root-knot), and *Rotylenchulus reniformis* (reniform) is greatly reduced at low moisture levels (1,7,11). Hatching of larvae from eggs of *Heterodera rostochiensis* (cyst), *Meloidogyne arenaria* (root-knot), and *Ditylenchus dipsaci* (stem and bulb nematode) is reduced at low moisture, but eggs which are inhibited from hatching may survive and hatch when moisture conditions in the soil are favorable (2). There is also evidence that fewer nematodes survive at low soil moisture levels, especially at levels near or below the permanent wilting point of host plants. *Hoplolaimus tylenchiformis* (lance) and *Paratylenchus projectus* (pin) nematodes, survived for less than 2 days in air-dried soil (8). In a soil at approximately 10% field capacity, *Meloidogyne* sp. (root-knot) larvae survived less than 5 days, and populations of *Tylenchorhynchus martini* (stunt) nematodes were reduced 90% (6,10).

Fallow has been used successfully to control plant parasitic nematodes. Nematode populations may be suppressed by starvation during the fallow, but in tropical countries with an extended dry season the negative effects of low soil moisture may have an even greater role in suppressing nematode populations during fallow. Summer fallow and frequent discing has also been successfully used to control *Xiphinema bakeri* (dagger nematode) in Douglas fir nurseries in Canada. Researchers have shown that during fallow and discing the moisture tensions and soil temperature exceeded lethal threshold levels and thereby controlled this nematode (14).

Evidence That Desiccation Often Does Not Eradicate Nematodes

Some plant parasitic nematodes are known to undergo anhydrobiosis or endure desiccation for long periods of time during which they remain in a state of quiescence or low metabolic activity. Some species undergo cryptobiosis or enter such extreme dormancy that no function of living systems appears to be present, and no metabolic activity can be detected with current methods. When favorable environmental conditions return, however, these nematodes take up moisture, revive rapidly, and resume normal activities. The seed and leaf gall nematode, *Anguina tritici*, was revived after 28 years of anhydrobiosis, and the stem and bulb nematode, *Ditylenchus dipsaci*, was revived after 23 years (3). In the genus *Heterodera*, the body wall of the mature swollen female forms a cyst which protects the egg from desiccation. The soybean cyst nematodes, *Heterodera glycines*, is able to survive for 3 years in air-dried soil. However, it survives for shorter periods in dry soil than moist soil, since in moist soil it may survive up to 8 years (13). In certain conditions other plant parasitic nematodes are able to survive desiccation for extended periods of time. Although various soils and experimental techniques were used, survival of plant parasitic nematodes in dry soils has been reported by various researchers for the following periods: *Tylenchorhynchus brevidens* (stunt), 15 months; *Pratylenchus minyus* (lesion), 13 months; *Hoplolaimus columbus* (lance), 12 months; *Helicotylenchus nannus* (spiral), 7 months; *Rotylenchulus reniformis* (reniform), 7 months; *Meloidogyne javanica* (root-knot), 20 weeks; *Pratylenchus penetrans*, 13 weeks; and *Pratylenchus brachyurus*, 4 months (8,12). Many plant parasitic nematodes are known to be wind-borne, which is further evidence that they can withstand desiccation. The following genera are among 28 genera of nematodes that are known to survive after being wind-borne in dust or soil: *Aphelenchoides* (bud and leaf), *Criconemoides* (ring), *Ditylenchus* (stem and bulb), *Helicotylenchus* (spiral), *Meloidogyne* (root-knot), *Pratylenchus* (lesion), and *Tylenchorhynchus* (stunt) (9).

In addition to differences between species, there is also variation in the susceptibility of developmental stages of the same species to desiccation. For *Tylenchorhynchus dubius* (stunt) and *Rotylenchus robustus* (spiral) the order of increasing susceptibility is: L 3 and L 4 larvae; females; males, L 2

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larvae (12). Eggs of these species are very susceptible to desiccation (12). For *Xiphinema bakeri* (dagger) the early development stages (L 2 and L 3) appear to be more sensitive to low soil moisture than the preadults and adults (L 4 and L 5) (4,14).

Other Factors Affecting Nematode Survival at Low Moisture

The rate at which desiccation occurs is the most critical factor affecting nematode survival at low moisture. With very rapid desiccation few plant parasitic nematodes survive, but if it occurs slowly as it often does in the soil, then a high percentage of the population survive for extended periods of time (12). The survival of *Aphelenchoides besseyi* (foliar nematode) is inversely related to the extent and rate of dehydration, and likewise the survival of *Heterodera schactii* (cyst nematode) appeared to be a function of the rate of drying (5,15).

Temperature influences nematode survival in dry soil. At 8, 12, 16, or 20 C the soybean cyst nematode, *Heterodera glycines* survived for 6 years, whereas at 24 and 28 C it only survived for 30 months (13).

Soil type affects the survival of nematodes at high moisture tensions. The lesion nematode, *Pratylenchus penetrans*, survived longer in clay soil with high moisture tensions than in sandy soil at the same moisture tensions (7). In air-dry clay soil the soybean-cyst nematode survived 38 months, but in sandy soil it survived 29 months (13).

Applications for Control of Nematodes

Research to date indicates that many nematodes have mechanisms to survive very dry conditions for extended periods of time. Therefore, this must be considered in developing good sanitation practices. It should not be assumed that nematodes cannot survive in dried soil that may be transferred on shoes, implements, or plant bulbs.

Research has also indicated that with some extraction methods it is more difficult to recover nematodes from dry soil. Therefore, care should also be taken in collecting and handling samples for analyses of nematode populations. When possible the soil that is collected for analyses of nematodes should be moist, not excessively dry. However, sampling and sending very wet soil should be avoided, since fewer nematodes will survive and be detected in very wet soil.

Although it is generally difficult to eradicate nematodes by limiting soil moisture, low soil moisture and especially rapid desiccation generally reduces nematode populations. Further studies may indicate how growers may most efficiently alter moisture to control plant parasitic nematodes in a management system.

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